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# FLOOD INSURANCE STUDY

## CITY OF MIDLAND, MICHIGAN

### MIDLAND AND BAY COUNTIES

REVISED

JANUARY 5, 1989

Federal Emergency Management Agency

COMMUNITY NUMBER - 260140

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

This publication incorporates revisions to the original Flood Insurance Study. These revisions are presented in Section 9.0.

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FLOOD INSURANCE STUDY

CITY OF MIDLAND,
MIDLAND COUNTY, MICHIGAN

# 1.0 INTRODUCTION

## 1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Midland, Midland County, Michigan, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert the City of Midland to the regular program of flood insurance by the Federal Emergency Management Agency (FEMA). Local and regional planners will use this study in their efforts to promote sound flood plain management.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these federally-supported studies are based. These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 44 CFR, 60.3. In such cases, however, it shall be understood that the state (or other jurisdictional agency) shall be able to explain these requirements and criteria.

## 1.2 Authority and Acknowledgements

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by Gove Associates, Inc., (the Study Contractor) for the Federal Emergency Management Agency, under Contract No. H-4728. This study was completed in December 1981.

## 1.3 Coordination

Information relevant to the Flood Insurance Study in the City of Midland was requested from local officials, the East Central Michigan Planning and Development Region, the U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers (COE), and the Michigan Department of Natural Resources. Periodic informational contacts were made with the City of Midland during the course of the study.

As state-coordinating agency, the Michigan Department of Natural Resources, Water Management Division, assisted in the selection of flooding sources to be studied and reviewed and approved the hydrologic and hydraulic calculations.

The initial coordination meeting was held on November 20, 1978 with representatives of the City of Midland, FEMA, the Department of Natural Resources, and the Study Contractor attending.

On July 14, 1982, the results of the work by the Study Contractor were reviewed and accepted at a final coordination meeting attended by representatives of the Study Contractor, FEMA, and the community.

## 2.0 AREA STUDIED

### 2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the City of Midland, Midland County, Michigan. The area of study is shown on the Vicinity Map (Figure 1).

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through December 1986.

Approximate methods of analysis were used to study those areas having a low development potential or minimal flood hazards as identified at the initiation of the study. The scope and methods of study were proposed to and agreed upon by FEMA and the City of Midland.

The following streams were studied in detail within the city boundaries of Midland:

a. The Tittabawassee River, from 900 feet downstream of the Consumers Power Company railroad to Dublin Road, approximately 6.1 miles;

b. The Chippewa River, from its mouth to approximately 2.6 miles upstream of the mouth;

c. Sturgeon Creek, from its confluence with the Tittabawassee River to the corporate limits, approximately 4 miles;

d. Inman (State) Drain, from its confluence with Sturgeon Creek to Dublin Road, approximately 2 miles; and

e. Snake Creek, from its confluence with the Tittabawassee River, to East Wackerly Road, approximately 3.2 miles.

A portion of the Tittabawassee River was studied by approximate methods.

### 2.2 Community Description

The City of Midland is located in east-central Midland County, which is approximately 130 miles northwest of Detroit, and 15 miles west of Saginaw Bay. Midland is the county seat for Midland County, and was originally settled in approximately 1833 and incorporated as a city in 1883. The city is located on the confluence of the Tittabawassee and Chippewa Rivers and is served by U.S. Highway 10 and State Highway 20. The City of Midland is surrounded by the following townships: Township of Midland to the south, Township of Homer to the west, Township of Larkin to the north, and Township of Williams of Bay County to the east.

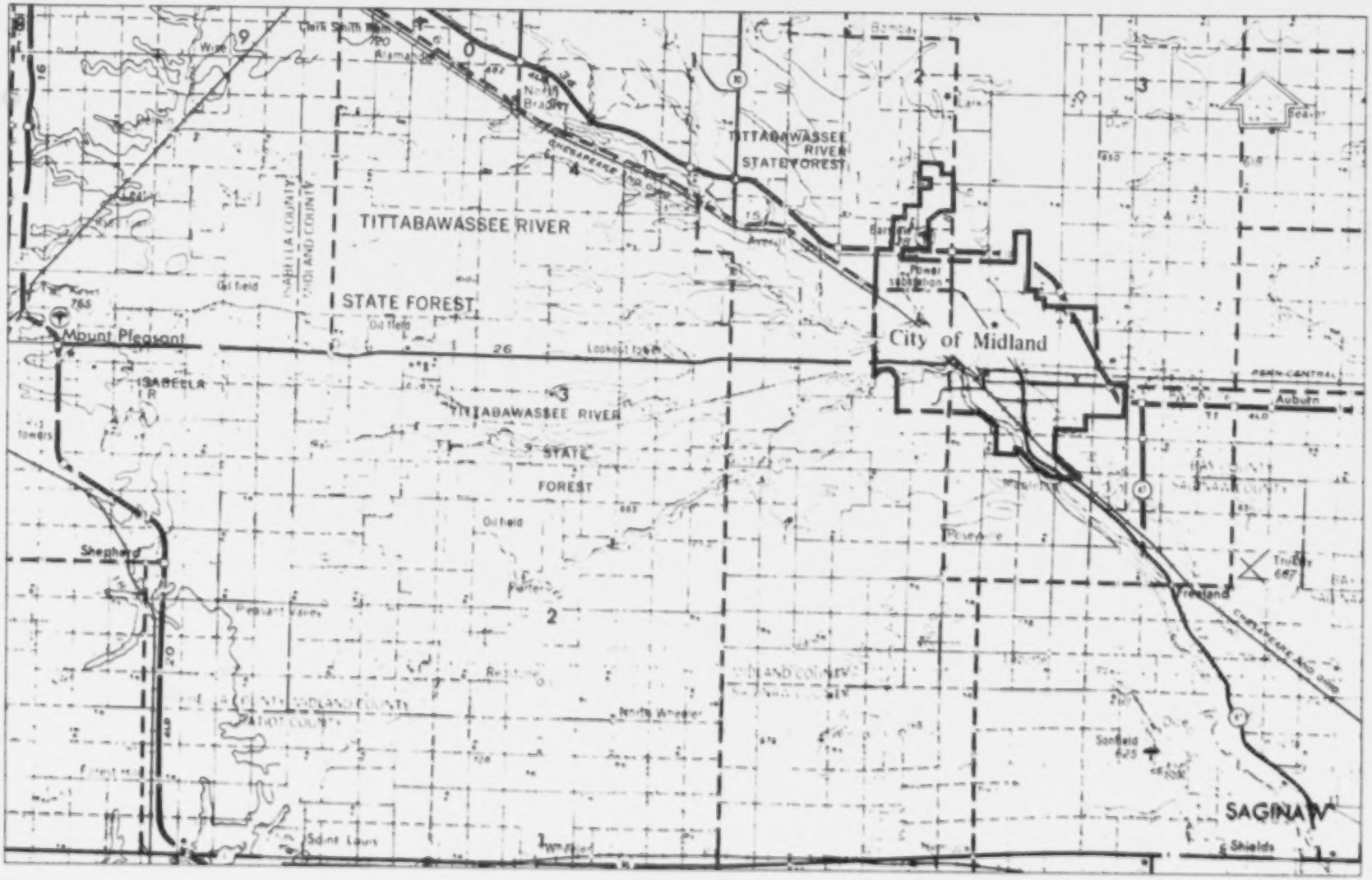



FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

**CITY OF MIDLAND, MI**
**(MIDLAND AND BAY COS.)**

APPROXIMATE SCALE

4 0 4 8 12 MILES

**VICINITY MAP**

The population of Midland in 1970 was 35,176 and the 1980 population was estimated to be 37,290 (Reference 1).

Midland's distance from the Great Lakes substantially reduces the climatic influence, and as a result, the climate is continental in character. The average minimum daily temperature in the winter is 16.0 degrees Fahrenheit (F.) and the average maximum daily summer temperature is 82.8 degrees F. Average annual precipitation is 29.6 inches, which includes an average annual snowfall of 36.3 inches (Reference 2).

The topography of the City of Midland is typical of central Michigan, gently rolling with some limited areas of sharper relief near the river systems. The soils are mostly loams and clay loams to the south and east, with sandy loams dominant in the west and northern portions of the county. Major agricultural crops raised in the area include beans, corn, and wheat (Reference 3).

The Tittabawassee River, which flows from east to southwest through the city, is the major stream within the community. The Chippewa River flows from east to west and meets with the Tittabawassee River within the city limits. Sturgeon Creek flows from north to south and discharges to the Tittabawassee River. The Inman (State) Drain is a tributary of Sturgeon Creek. Snake Creek is also a tributary of the Tittabawassee River and flows in a north-to-south direction to its confluence with the Tittabawassee River.

Approximately 65 percent of the land area within the city is developed, with about 20 percent of the total area in residential use and 10 percent in heavy industrial use. Within the flood plains of the streams studied in detail, the land uses include residential, commercial, and industrial development. Along the Tittabawassee River flood plain, a major portion of the river shoreline is developed for industrial purposes.

## 2.3 Principal Flood Problems

Flooding occurs in the City of Midland when high runoff causes the principle flooding sources (Tittabawassee River, Chippewa River, Snake Creek, Sturgeon Creek, or Inman (State) Drain) to overflow their banks. A USGS gage is located on the Tittabawassee River (No. 04156000) approximately 0.25 mile downstream of the Dow Chemical Company Dam. A gage is also located on the Chippewa River (No. 04154500) upstream of the city limits. The maximum recorded flow at the Midland gage of the Tittabawassee River was recorded in 1916 with a flow of 34,800 cubic feet per second (cfs). A similar flow of 34,000 cfs was recorded during the 1948 flood of the Tittabawassee River. Each of these floods was slightly less than the predicted 50-year flood for the Tittabawassee River. In 1976, a flow of 26,400 cfs, the approximate equivalent to the expected 10-year storm, was recorded at the gage (Reference 4).

## 2.4 Flood Protection Measures

Due to the intensive industrial development along the Tittabawassee River, many areas that are developed have been filled above the normal flood stage of the Tittabawassee River. This fill area effectively limits the boundary of the 100-year flood and removes much of the industrial area from the flood plain. The area of the nuclear power plant development also has been extensively filled to eliminate that area from the flood plain of the Tittabawassee River. Along the Chippewa River, some filling has also occurred which serves to protect against periodic annual flooding but not for the higher levels of the 100-year flood.

# 3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

## 3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail affecting the community.

Frequency relationships for the Tittabawassee and Chippewa Rivers, which are gaged streams, were determined by statistical analysis using the log-Pearson Type III method (Reference 5). For the Chippewa River analysis, 29 years of records were analyzed at USGS gage No. 04154500, and for the Tittabawassee River, the analysis was based upon the 66 years of data available at USGS gage No. 04156000.

The peak discharges for Sturgeon Creek and Inman (State) Drain, which are ungaged streams, were determined utilizing the U.S. Department of Agriculture, Soil Conservation Service (SCS) methodology for "Estimation of Direct Runoff from Storm Rainfall" as outlined in the SCS National Engineering Handbook (Reference 6). The flood flows for Snake Creek were developed by combining the data obtained from the SCS method with that developed by the technique outlined in "Rainfall-Runoff Relations on Urban and Rural Areas" (Reference 7). Due to the developed urban nature of the Snake Creek basin, combining these two methods produced the most accurate estimation of the flood flows from the basin.

Peak discharges for the 10-, 50-, 100-, and 500-year floods of each flooding source studied in detail in the community are shown in Table 1.

## 3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the streams in the community were carried out to provide estimates of the elevations of the floods of the selected recurrence intervals along each flooding source studied in detail.

Cross sections for the backwater analysis of each of the streams studied were obtained by field surveys in the flood plain and channel sections. Field surveys were completed during fall 1979. All bridges and dams were field checked to obtain elevation data and structural geometry.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles. For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map.

Roughness coefficients (Manning's "n") for each of the streams were estimated by field inspection at each cross section at the time of the field measurement. These estimates were then compared with the photographs and descriptions in Open-Channel Hydraulics (Reference 8) to obtain the final values. The resulting roughness factors for the channel and in the overbank areas are presented in the table below.

| | Overbanks | Channel |
|---|---|---|
| Tittabawassee River | 0.03 - 0.06 | 0.03 - 0.035 |
| Chippewa River | 0.06 | 0.035 |
| Snake Creek | 0.03 - 0.12 | 0.03 - 0.055 |
| Sturgeon Creek | 0.035 - 0.1 | 0.035 - 0.05 |
| Inman (State) Drain | 0.04 - 0.1 | 0.031 - 0.045 |

Elevations for the area studied by approximate methods were determined by normal depth analysis and engineering judgment.

TABLE 1 - SUMMARY OF DISCHARGES

| FLOODING SOURCE AND LOCATION | DRAINAGE AREA SQ MILES | PEAK DISCHARGES (CFS) 10-YEAR | 50-YEAR | 100-YEAR | 500-YEAR |
|---|---|---|---|---|---|
| TITTABAWASSEE RIVER | | | | | |
| At Mapleton | 2,448 | 28,000 | 41,700 | 47,800 | 62,700 |
| At USGS gage about 1,300 feet downstream of Dow Chemical Company Dam | 2,400 | 27,500 | 41,000 | 47,000 | 61,600 |
| Upstream of confluence of Chippewa River | 1,386 | 17,700 | 26,400 | 30,300 | 39,700 |
| CHIPPEWA RIVER | | | | | |
| At confluence with Tittabawassee River | 1,011 | 10,500 | 15,000 | 16,900 | 21,700 |
| SNAKE CREEK | | | | | |
| At mouth | 4.67 | 900 | 1,170 | 1,300 | 1,600 |
| Upstream of confluence of Unnamed Tributary | 2.50 | 480 | 640 | 710 | 860 |
| At Sylvan Lake | 1.60 | 450 | 600 | 660 | 800 |
| STURGEON CREEK | | | | | |
| At mouth | 58.85 | 1,050 | 1,600 | 1,850 | 2,500 |
| Upstream of Inman Drain | 51.55 | 900 | 1,400 | 1,600 | 2,200 |
| INMAN (STATE) DRAIN | | | | | |
| At confluence with Sturgeon Creek | 7.29 | 330 | 470 | 540 | 700 |

Expansion and contraction coefficients for the streams were estimated from data obtained from the COE (Reference 9).

The starting water-surface elevations for the HEC-2 profiles for the Tittabawassee River were obtained using the rating curve developed in the COE report (Reference 10) to calibrate starting water-surface elevations. The rating curve at the gaging station was used to check continuity. The starting elevation for the Chippewa River was based upon the flood elevations of the Tittabawassee River at the confluence. For Snake Creek and Sturgeon Creek, the starting water-surface elevation was the mean annual high water elevation of the Tittabawassee River. Inman (State) Drain HEC-2 runs were begun at the flood elevations of Sturgeon Creek.

Water-surface profiles for the 10-, 50-, 100-, and 500-year floods were developed using the COE HEC-2 step-backwater computer program (Reference 11).

Flood profiles were drawn showing the computed water-surface elevations for floods of the selected recurrence intervals.

The hydraulic analyses for this study are based only on the effects of unobstructed flow. The flood elevations as shown on the profiles are, therefore, considered valid only if hydraulic structures, in general, remain unobstructed and if channel and overbank conditions remain essentially the same as ascertained during this study.

All elevations are referenced from National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in the study are shown on the maps.

## 4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

### 4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by FEMA as the base flood for purposes of flood plain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the boundaries of the 100-year and the 500-year floods have been delineated using the elevations determined at each cross section; between cross sections the boundaries were interpolated using topographic maps at a scale of 1:24000, 1:600, 1:1200, and 1:2400 with contour intervals of 2 and 5 feet (References 12, 13, 14, and 15).

Flood boundaries for the area studied by approximate methods were delineated using the above referenced topographic maps.

The boundaries of the 100- and 500-year floods are shown on the Flood Boundary and Floodway Map. Small areas within the flood boundaries may lie above the flood elevations and, therefore, not be subject to flooding; owing to lack of detailed topographical information or to limitations of the map scale, such areas are not shown. In cases where the 100-year and the 500-year flood boundaries are close together, only the 100-year boundary has been shown.

## 4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of FEMA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. The Michigan Flood Plain Act (Act 167, P.A. 1968), however, limits flood plain encroachments to that which will cause only insignificant increases in flood heights (less than 0.1 foot) (Reference 16). Thus, a floodway having no more than 0.1-foot surcharge has been delineated for this study.

The floodways for each of the streams studied in detail were determined by defining the sweep and extent of moving floodwaters, using basic rules of hydraulics. Areas that are considered to have no water-carrying capability or areas containing non-moving waters are not included in the floodway. The results of these computations were tabulated at selected cross sections for each stream segment for which a floodway was computed (Table 2). Portions of the floodway lie outside the corporate limits.

As shown on the Flood Boundary and Floodway Map, the floodway widths were determined at cross sections; between cross sections, the boundaries were interpolated. In cases where the boundaries of the floodway and the 100-year flood are either close together or collinear, only the floodway boundary has been shown.

| FLOODING SOURCE | | FLOODWAY | | | BASE FLOOD WATER SURFACE ELEVATION | | | |
|---|---|---|---|---|---|---|---|---|
| CROSS SECTION | DISTANCE[1] | WIDTH (FEET) | SECTION AREA (SQ. FEET) | MEAN VELOCITY (FEET/SEC.) | REGULATORY (NGVD) | WITHOUT FLOODWAY (NGVD) | WITH FLOODWAY (FEET) | INCREASE |
| TITTABAWASSEE RIVER | | | | | | | | |
| A | 112,974 | 476 | 10,101 | 4.7 | 610.5 | 610.5 | 610.6 | 0.1 |
| B | 113,884 | 696 | 11,732 | 4.1 | 610.8 | 610.8 | 610.9 | 0.1 |
| C | 116,484 | 713 | 12,114 | 3.9 | 611.2 | 611.2 | 611.3 | 0.1 |
| D | 117,657 | 504 | 9068 | 5.3 | 611.4 | 611.4 | 611.5 | 0.1 |
| E | 118,217 | 524 | 9474 | 5.0 | 611.6 | 611.6 | 611.7 | 0.1 |
| F | 120,117 | 682/140[2] | 13,327 | 3.6 | 612.2 | 612.2 | 612.3 | 0.1 |
| G | 121,617 | 501/100[2] | 8026 | 5.9 | 612.2 | 612.2 | 612.3 | 0.1 |
| H | 122,517 | 629/160[2] | 9351 | 5.0 | 612.6 | 612.6 | 612.7 | 0.1 |
| I | 123,725 | 566 | 7573 | 7 0 | 612.9 | 612.9 | 613.0 | 0.1 |
| J | 124,204 | 296 | 5700 | 8.2 | 613.3 | 613.3 | 613.3 | 0.0 |
| K | 124,397 | 314 | 6838 | 6.9 | 613.7 | 613.7 | 613.7 | 0.0 |
| L | 124,807 | 670 | 8431 | 6.2 | 614.0 | 614.0 | 614.0 | 0.0 |
| M | 127,481 | 508 | 8873 | 5.6 | 614.7 | 614.7 | 614.7 | 0.0 |
| N | 130,129 | 560 | 7593 | 4.6 | 615.4 | 615.4 | 615.4 | 0.0 |
| O | 130,559 | 993 | 14,156 | 2.5 | 615.6 | 615.6 | 615.6 | 0.0 |
| P | 131,528 | 1660 | 15,140 | 1.3 | 615.7 | 615.7 | 615.7 | 0.0 |
| Q | 131,579 | 1660 | 17,731 | 2.0 | 615.7 | 615.7 | 615.7 | 0.0 |
| R | 133,279 | 1980 | 23,764 | 2.4 | 615.8 | 615.8 | 615.8 | 0.0 |
| S | 135,679 | 2500 | 27,614 | 2.3 | 615.9 | 615.9 | 615.9 | 0.0 |
| T | 137,179 | 2750 | 28,278 | 2.2 | 616.0 | 616.0 | 616.0 | 0.0 |
| U | 139,629 | 2280 | 21,235 | 3.0 | 616.1 | 616.1 | 616.1 | 0.0 |
| V | 142,129 | 2400 | 26,641 | 2.4 | 616.3 | 616.3 | 616.3 | 0.0 |

[1]FEET ABOVE MOUTH
[2]TOTAL WIDTH / WIDTH WITHIN CORPORATE LIMITS

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MIDLAND, MI

(MIDLAND AND BAY COS.)

FLOODWAY DATA

TITTABAWASSEE RIVER

| FLOODING SOURCE | | FLOODWAY | | | BASE FLOOD WATER SURFACE ELEVATION | | | |
|---|---|---|---|---|---|---|---|---|
| CROSS SECTION | DISTANCE[1] | WIDTH (FEET) | SECTION AREA (SQ. FEET) | MEAN VELOCITY (FEET/SEC.) | REGULATORY (NGVD) | WITHOUT FLOODWAY (NGVD) | WITH FLOODWAY (FEET) | INCREASE |
| CHIPPEWA RIVER | | | | | | | | |
| A | 3250 | 1356 | 18,021 | 1.6 | 616.1 | 616.1 | 616.1 | 0.0 |
| B | 5950 | 2300 | 22,404 | 1.6 | 616.2 | 616.2 | 616.2 | 0.0 |
| C | 8500 | 2350 | 23,294 | 1.6 | 616.2 | 616.2 | 616.2 | 0.0 |
| D | 11,850 | 2750/115[3] | 32,320 | 1.6 | 616.3 | 616.3 | 616.3 | 0.0 |
| STURGEON CREEK | | | | | | | | |
| A | 713[2] | 221 | 3509 | 0.5 | 615.9 | 608.9[4] | 608.9 | 0.0 |
| B | 2033[2] | 374 | 4394 | 0.4 | 615.9 | 608.9[4] | 608.9 | 0.0 |
| C | 3848[2] | 321 | 2908 | 0.6 | 615.9 | 608.9[4] | 608.9 | 0.0 |
| D | 5675[2] | 32 | 282 | 6.6 | 615.9 | 609.3[4] | 609.3 | 0.0 |
| E | 6590[2] | 230 | 1669 | 1.0 | 615.9 | 610.2[4] | 610.3 | 0.1 |
| F | 7830[2] | 230 | 1875 | 0.9 | 615.9 | 610.3[4] | 610.4 | 0.1 |
| G | 8440[2] | 310 | 2073 | 0.8 | 615.9 | 610.3[4] | 610.4 | 0.1 |
| H | 8718[2] | 62 | 470 | 3.4 | 615.9 | 610.3[4] | 610.4 | 0.1 |
| I | 10,053[2] | 318 | 2198 | 0.7 | 615.9 | 610.7[4] | 610.8 | 0.1 |
| J | 12,033[2] | 250 | 1539 | 1.0 | 615.9 | 610.9[4] | 611.0 | 0.1 |
| K | 12,833[2] | 205 | 1037 | 1.5 | 615.9 | 611.1[4] | 611.2 | 0.1 |
| L | 14,233[2] | 239 | 1073 | 1.5 | 615.9 | 611.7[4] | 611.8 | 0.1 |
| M | 15,767[2] | 30/15[3] | 265 | 6.0 | 615.9 | 612.7[4] | 612.8 | 0.1 |
| N | 16,216[2] | 40 | 442 | 3.6 | 615.9 | 613.6[4] | 613.7 | 0.1 |
| O | 16,328[2] | 40 | 407 | 3.9 | 615.9 | 613.7[4] | 613.8 | 0.1 |
| P | 17,293[2] | 335 | 1387 | 1.2 | 615.9 | 614.1[4] | 614.1 | 0.0 |
| Q | 18,474[2] | 320 | 1193 | 1.3 | 615.9 | 614.3[4] | 614.3 | 0.0 |
| R | 20,111[2] | 189 | 805 | 2.0 | 615.9 | 614.7[4] | 614.7 | 0.0 |

[1]FEET ABOVE MOUTH
[2]FEET ABOVE CONFLUENCE WITH TITTABAWASSEE RIVER
[3]TOTAL WIDTH / WIDTH WITHIN CORPORATE LIMITS
[4]ELEVATIONS WITHOUT CONSIDERING BACKWATER EFFECT FROM TITTABAWASSEE RIVER

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

# CITY OF MIDLAND, MI

(MIDLAND AND BAY COS.)

## FLOODWAY DATA

## CHIPPEWA RIVER - STURGEON CREEK

| FLOODING SOURCE | | FLOODWAY | | | BASE FLOOD WATER SURFACE ELEVATION | | | |
|---|---|---|---|---|---|---|---|---|
| CROSS SECTION | DISTANCE[1] | WIDTH (FEET) | SECTION AREA (SQ. FEET) | MEAN VELOCITY (FEET/SEC.) | REGULATORY (FEET NGVD) | WITHOUT FLOODWAY (FEET NGVD) | WITH FLOODWAY (FEET NGVD) | INCREASE (FEET) |
| SNAKE CREEK | | | | | | | | |
| A | 1078 | 105 | 1715 | 0.8 | 615.9 | 606.3[2,3] | 606.3[3] | 0.0 |
| B | 1688 | 258 | 2569 | 0.5 | 615.9 | 607.0[2,3] | 607.0[3] | 0.0 |
| C | 3228 | 210 | 2110 | 0.6 | 615.9 | 609.1[2,3] | 609.1[3] | 0.0 |
| D | 3959 | 135 | 1487 | 0.9 | 615.9 | 610.2[2,3] | 610.2[3] | 0.0 |
| E | 4409 | 130 | 986 | 1.3 | 615.9 | 610.8[2,3] | 610.8[3] | 0.0 |
| F | 4593 | 16 | 220 | 5.9 | 615.9 | 611.0[2,3] | 611.0[3] | 0.0 |
| G | 5313 | 290 | 2530 | 0.5 | 615.9 | 612.0[2,3] | 612.0[3] | 0.0 |
| H | 6012 | 270 | 1484 | 0.9 | 615.9 | 613.0[2,3] | 613.0[3] | 0.0 |
| I | 6792 | 168 | 707 | 4.6 | 615.9 | 614.2[2,3] | 614.3[3] | 0.1 |
| J | 8118 | 236 | 697 | 7.2 | 616.9 | 616.9 | 617.0 | 0.1 |
| K | 8788 | 200 | 1421 | 2.5 | 618.0 | 618.0 | 618.1 | 0.1 |
| L | 9763 | 23 | 82 | 6.9 | 618.0 | 618.0 | 618.1 | 0.1 |
| M | 9943 | 75 | 180 | 4.1 | 620.0 | 620.0 | 620.0 | 0.0 |
| N | 10,359 | 150 | 514 | 1.2 | 625.1 | 625.1 | 625.1 | 0.0 |
| O | 10,459 | 140 | 670 | 0.8 | 625.1 | 625.1 | 625.1 | 0.0 |
| P | 11,429 | 200 | 514 | 1.5 | 628.0 | 628.0 | 628.0 | 0.0 |
| Q | 12,139 | 300 | 519 | 1.6 | 628.2 | 628.2 | 628.2 | 0.0 |
| R | 13,138 | 120 | 326 | 2.0 | 628.8 | 628.8 | 628.8 | 0.0 |
| S | 13,889 | 49 | 260 | 1.6 | 629.0 | 629.0 | 629.0 | 0.0 |
| T | 14,509 | 38 | 146 | 2.1 | 629.2 | 629.2 | 629.2 | 0.0 |
| U | 14,905 | 80 | 345 | 1.3 | 632.7 | 632.7 | 632.7 | 0.0 |
| V | 15,955 | 92 | 351 | 0.6 | 632.8 | 632.8 | 632.8 | 0.0 |
| W | 16,900 | 32 | 88 | 1.7 | 632.9 | 632.9 | 632.9 | 0.0 |

[1]FEET ABOVE CONFLUENCE WITH TITTABAWASSEE RIVER
[2]ELEVATIONS WITHOUT CONSIDERING THE BACKWATER EFFECT FROM TITTABAWASSEE RIVER
[3]ELEVATIONS DETERMINED BY APPROXIMATE METHODS

REVISED 1/5/89

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

**CITY OF MIDLAND, MI**
**(MIDLAND AND BAY COS.)**

**FLOODWAY DATA**

**SNAKE CREEK**

| FLOODING SOURCE | | FLOODWAY | | | BASE FLOOD WATER SURFACE ELEVATION | | | |
|---|---|---|---|---|---|---|---|---|
| CROSS SECTION | DISTANCE[1] | WIDTH (FEET) | SECTION AREA (SQ. FEET) | MEAN VELOCITY (FEET/SEC.) | REGULATORY (NGVD) | WITHOUT FLOODWAY [2] (NGVD) | WITH FLOODWAY (NGVD) | INCREASE (FEET) |
| INMAN DRAIN | | | | | | | | |
| A | 1190 | 325 | 195 | 2.8 | 615.9 | 602.6 | 602.7 | 0.1 |
| B | 2950 | 20 | 113 | 4.8 | 615.9 | 608.2 | 608.2 | 0.0 |
| C | 3711 | 225 | 460 | 1.2 | 615.9 | 609.3 | 609.3 | 0.0 |
| D | 4552 | 26 | 111 | 4.9 | 615.9 | 609.8 | 609.8 | 0.0 |
| E | 5853 | 100 | 260 | 2.1 | 615.9 | 611.1 | 611.1 | 0.0 |
| F | 6721 | 13 | 81 | 6.6 | 615.9 | 612.3 | 612.3 | 0.0 |
| G | 7692 | 129 | 346 | 1.6 | 615.9 | 613.3 | 613.3 | 0.0 |
| H | 9447 | 130 | 386 | 1.4 | 615.9 | 613.7 | 613.7 | 0.0 |

[1]FEET ABOVE CONFLUENCE WITH STURGEON CREEK
[2]ELEVATIONS WITHOUT CONSIDERING BACKWATER EFFECT FROM TITTABAWASSEE RIVER

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

**CITY OF MIDLAND, MI**
**(MIDLAND AND BAY COS.)**

**FLOODWAY DATA**

**INMAN DRAIN**

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 0.1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 2.

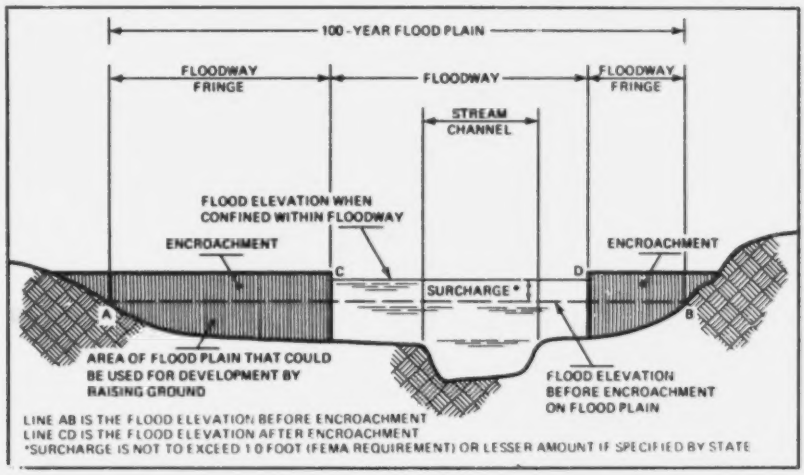

100-YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE

FIGURE 2 - Floodway Schematic

The floodways in this report are recommended to local agencies as minimum standards that can be adopted or that can be used as a basis for additional studies.

## 5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, FEMA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors (FHF), and flood insurance zone designations for each flooding source affecting the City of Midland.

### 5.1 Reach Determinations

Reaches are defined as lengths of watercourses having relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference does not have a variation greater than that indicated in the following table for more than 20 per cent of the reach.

| Average Difference Between 10- and 100-year Floods | Variation |
|---|---|
| Less than 2 feet | 0.5 foot |
| 2 to 7 feet | 1.0 foot |
| 7.1 to 12 feet | 2.0 feet |
| More than 12 feet | 3.0 feet |

The locations of the reaches determined for the City of Midland are shown on the Flood Profiles and are summarized in Table 3, Flood Insurance Zone Data.

## 5.2 Flood Hazard Factors

The FHF is used to correlate flood information with insurance rate tables. Correlations between property damage from floods and their FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations expressed to the nearest 0.5 foot, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year flood water-surface elevations is greater than 10.0 feet, accuracy for the FHF is to the nearest foot.

## 5.3 Flood Insurance Zones

After the determination of reaches and their respective FHFs, the entire incorporated area of the City of Midland was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations:

| | |
|---|---|
| Zone A: | Special Flood Hazard Areas inundated by the 100-year flood, determined by approximate methods; no base flood elevations are shown or FHFs determined. |
| Zones A1, A3, A8, A9, A11: | Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations are shown, and zones subdivided according to FHF. |
| Zone B: | Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; or areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided. |
| Zone C: | Areas of minimal flooding. |

Table 3, Flood Insurance Zone Data, summarizes the flood elevation differences, FHFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community.

### 5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Midland is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by FEMA.

## 6.0 OTHER STUDIES

The Tittabawassee River at Midland has been studied by the COE and Consumers Power Company (Reference 10). The purpose of the COE study was to evaluate flood protection measures in the city, while the Consumers Power Company study was to provide information related to the safety of the nuclear power plant.

The design flow of the COE report was the same as this study and the maximum elevation difference from this study and the COE report is 2.0 feet, which occurs upstream of the confluence with the Chippewa River. The maximum probable flood flow was used by the Consumers Power Company. The study characters and the study limits of the Consumers Power Company's report are different from this analysis, therefore, no comparison with their report was attempted.

A Flood Hazard Boundary Map has been published for the community (Reference 17). The differences between the Flood Hazard Boundary Map and this study are justified due to the more detailed nature of this Flood Insurance Study.

This report either supersedes or is compatible with all previous studies published on streams studied in this report and should be considered authoritative for the purposes of the National Flood Insurance Program.

## 7.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, Federal Emergency Management Agency, 300 South Wacker Drive, (24th Floor), Chicago, Illinois 60606.

| FLOODING SOURCE | PANEL[1] | ELEVATION DIFFERENCE[2] BETWEEN 1.0% (100-YEAR) FLOOD AND | | | FLOOD HAZARD FACTOR | ZONE | BASE FLOOD EIEVATION[3] (FEET NGVD) |
|---|---|---|---|---|---|---|---|
| | | 10% (10-YEAR) | 2% (50-YEAR) | 0.2% (500-YEAR) | | | |
| TITTABAWASEE RIVER | | | | | | | |
| REACH 1 | 0005,0007 | -4.3 | -1.2 | 2.9 | 045 | A9 | VARIES—SEE MAP |
| CHIPPEWA RIVER | | | | | | | |
| REACH 1 | 0007 | -5.5 | -1.6 | 3.9 | 055 | A11 | VARIES—SEE MAP |
| SNAKE CREEK | | | | | | | |
| REACH 1 | 0004 | -1.5 | -0.1 | 2.1 | 015 | A3 | VARIES—SEE MAP |
| REACH 2 | 0004 | -0.5 | -0.3 | 0.3 | 005 | A1 | VARIES—SEE MAP |
| REACH 3 | 0004 | -2.0 | -1.3 | 0.9 | 020 | A4 | VARIES—SEE MAP |

[1]FLOOD INSURANCE RATE MAP PANEL
[2]WEIGHTED AVERAGE
[3]ROUNDED TO NEAREST FOOT

REVISED: 1/5/89

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

**CITY OF MIDLAND, MI**
**(MIDLAND AND BAY COS.)**

## FLOOD INSURANCE ZONE DATA

## TITTABAWASSEE RIVER — CHIPPEWA RIVER — SNAKE CREEK

## 8.0 REFERENCES AND BIBLIOGRAPHY


1. State of Michigan, Population and Housing Unit Counts for the State by Counties and County Subdivisions: 1980 and 1970, 1980 Census, Preliminary Counts.

2. Michigan Department of Agriculture, Climate of Michigan by Stations, Lansing, Michigan, December 1971.

3. U.S. Department of Agriculture, Agricultural Research Administration, Soil Survey, Midland County, Michigan, May 1950.

4. U.S. Geological Survey Water-Data Report, U.S. Department of the Interior, Water Resources Data for Michigan, Water Year 1980.

5. U.S. Water Resources Council, Bulletin No. 17A, Guidelines for Determining Flood Flow Frequency, Washington, D.C., March 1976.

6. U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Chapter 7, "Hydrology, Estimation of Direct Runoff from Storm Rainfall," August 1972.

7. Brater, Ernest and James Sherill, Rainfall-Runoff Relations on Urban and Rural Areas, 1975.

8. Chow, Ven Te, Open Channel Hydraulics, New York: McGraw Hill Book Company, Inc., 1959.

9. U.S. Army Corps of Engineers, Hydrologic Engineering Center, Training Document No. 6, Application of the HEC-2 Bridge Routine, Davis, California, June 1974.

10. ————, Detroit District, Flood Control on Saginaw River, Michigan and Tributaries, Tittabawassee River at Midland; Phase I, Design Memorandum No. 8, Michigan, January 1977.

11. ————, HEC-2 Water-Surface Profiles Generalized Computer Program, Davis, California, November 1976.

12. U.S. Geological Survey, 7.5 Minute Series Topographic Maps, Midland North, Midland South, Scale 1:24000, Contour Interval 5 feet, 1962.

13. City of Midland, Michigan, Topographic Map of Huron Park, Scale 1:600, Contour Interval 2 feet: January 1975.

14. City of Midland, Michigan, Topographic Map, Scale 1:2400, Contour Interval 2 feet: 1975.

15. City of Midland, Michigan, Sturgeon Road Cemetery Development, Scale 1:1200.

16. State of Michigan, Flood Plain Control Act in 1968, Act 245, P.A. 1929 as amended by Act 167, P.O. 1968, Michigan Water Resources Commission, Lansing, Michigan, 1968.

17. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Hazard Boundary Map, City of Midland, Michigan, August 1975.

Consumers Power Company, Midland Plant Final Safety Analysis Report, August 1977.

## 9.0 REVISIONS DESCRIPTION

This section has been added to provide information regarding significant revisions made since the original Flood Insurance Study was printed. Future revisions may be made that do not result in the republishing of the Flood Insurance Study report. To assure that any user is aware of all revisions, it is advisable to contact the community repository of flood hazard data located at the Office of the City Clerk, Midland City Hall, 202 Ashman, Midland, Michigan.

### 9.1 First Revision (Revised January 5, 1989)

a. Acknowledgments

The hydrologic and hydraulic analyses for this Revisions Description were performed by McNamee, Porter, and Seeley, of Ann Arbor, Michigan. The Federal Emergency Management Agency reviewed and accepted these data for purposes of this revision.

b. Scope

The entire length of Snake Creek within the City of Midland was studied by McNamee, Porter, and Seeley, and the results were published in a report titled "City of Midland, Michigan, Stormwater Management Study, 100-Year Floodplain Analysis, Final Report" (Reference 18).

The maps were revised to include the recently annexed portions of the city and the areas of flooding within those annexed areas. Information regarding the annexed areas was obtained from corporate limits maps provided by the city (Reference 19). Inset A was added to Panel 0007 of the Flood Insurance Rate Map and the Flood Boundary and Floodway Map to show the annexed area west of Dublin Road between Highway 20 and the Tittabawassee River, and flooding shown is from the Tittabawassee River. An area that was annexed east of Sturgeon Creek between John Barstow Airport and Wackerly Road is shown on Panel 0006. The floodway and the 100- and 500-year floodplains for Sturgeon Creek were delineated in that area. As a result of an annexation on the north side of Wackerly Road, the Special Flood Hazard Area (SFHA) for Snake Creek was extended approximately 450 feet to the north, as shown on revised Panel 0004.

In addition to changes to the corporate limits, streets and street names were added to the revised panels.

c. Hydrologic and Hydraulic Analyses

McNamee, Porter, and Seeley performed HEC-1 hydrologic analyses (Reference 20) for the Snake Creek drainage basin and determined that the discharges for the 10-, 50-, 100-, and 500-year floods would be reduced. The discharges are shown in Table 4, Revised Summary of Discharges.

TABLE 4 - REVISED SUMMARY OF DISCHARGES

| FLOODING SOURCE AND LOCATION | DRAINAGE AREA (SQ MILES) | PEAK DISCHARGE (CFS) 10-YEAR | 50-YEAR | 100-YEAR | 500-YEAR |
|---|---|---|---|---|---|
| SNAKE CREEK | | | | | |
| at mouth | 5.50 | 1,150 | 2,250 | 2,300 | 3,400 |
| at Crescent Drive | 2.50 | 280 | 610 | 570 | 710 |
| at Sylvan Lane | 1.60 | 260 | 390 | 490 | 605 |

Water-surface profiles for the 10-, 50-, 100-, and 500-year floods, with revised discharges from the HEC-1 analysis, were developed using the HEC-2 step-backwater computer program (Reference 21). The 100- and 500-year floodplains and the 100-year floodway were then delincated using topographic maps at a scale of 1:1200 with a contour interval of 1 foot (Reference 22).

The corporate limits were revised to reflect annexations by the city. The areas of 100-year flooding for the annexation west of Dublin Road and at the upstream end of Snake Creek were delineated by approximate methods using a topographic map at a scale of 1:24000 with a contour interval of 5 feet (Reference 23). For the small annexed area along Sturgeon Creek, the 100- and 500-year floodplains and the 100-year floodway were delineated using topographic maps at a scale of 1:24000 with a contour interval of 5 feet (Reference 23).

d. Floodways

Floodway computations for Snake Creek were revised as a result of revised hydrologic and hydraulic analyses. The floodways were computed on the basis of equal conveyance reduction from each side of the floodplain. The results of these computations were tabulated at selected cross sections for each stream segment for which a floodway was revised and are presented in Table 2, Floodway Data.

The area between the floodway and the 100-year floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 0.10 foot at any point.

e. Other Studies

This report either supersedes or is compatible with all previous studies published on streams in the City of Midland and should be considered authoritative for purposes of the National Flood Insurance Program.

f. References and Bibliography


18. McNamee, Porter, and Seeley, City of Midland, Michigan, Stormwater Management Study, 100-Year Floodplain Analysis, Final Report, April 1984.

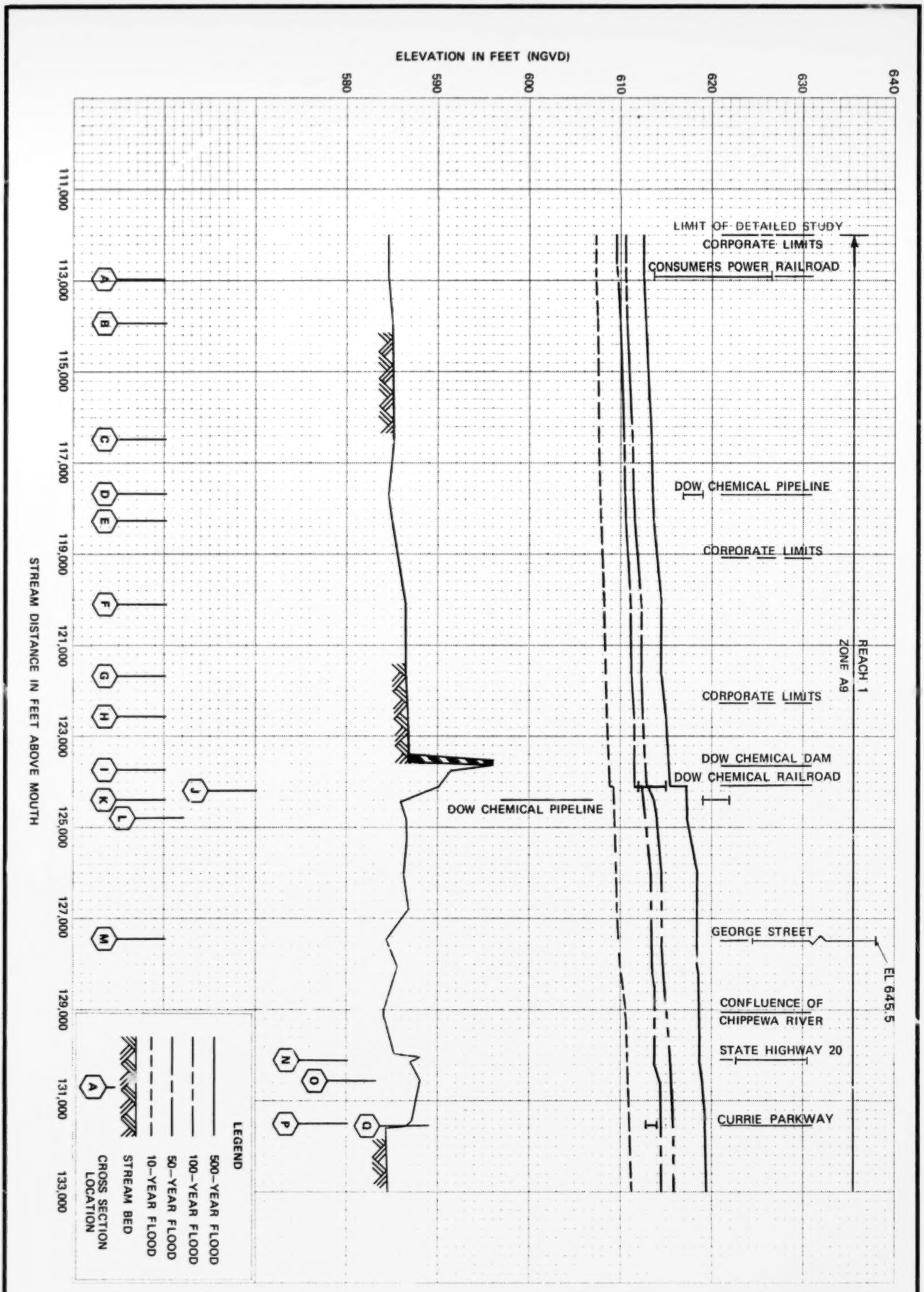
19. City of Midland, Michigan, Midland, Michigan, Zoning Map, Scale 1:12000, July 1987.

20. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Computer Program 823-X6-L2610, Davis, California, January 1973.

21. ————, Hydrologic Engineering Center, HEC-2 Water-Surface Profiles, Generalized Computer Program, Davis, California, April 1984.

22. Abrams Aerial Survey Corporation, City of Midland, Michigan, Scale 1:1200, Contour Interval 1 Foot: Midland, Michigan, 1983.

23. U.S. Geological Survey, 7.5 Minute Series Topographic Maps, Scale 1:24000, Contour Interval 5 Feet: Gordonville, Michigan, 1973; Averill, Michigan, 1973.

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| | | |
|---|---|---|
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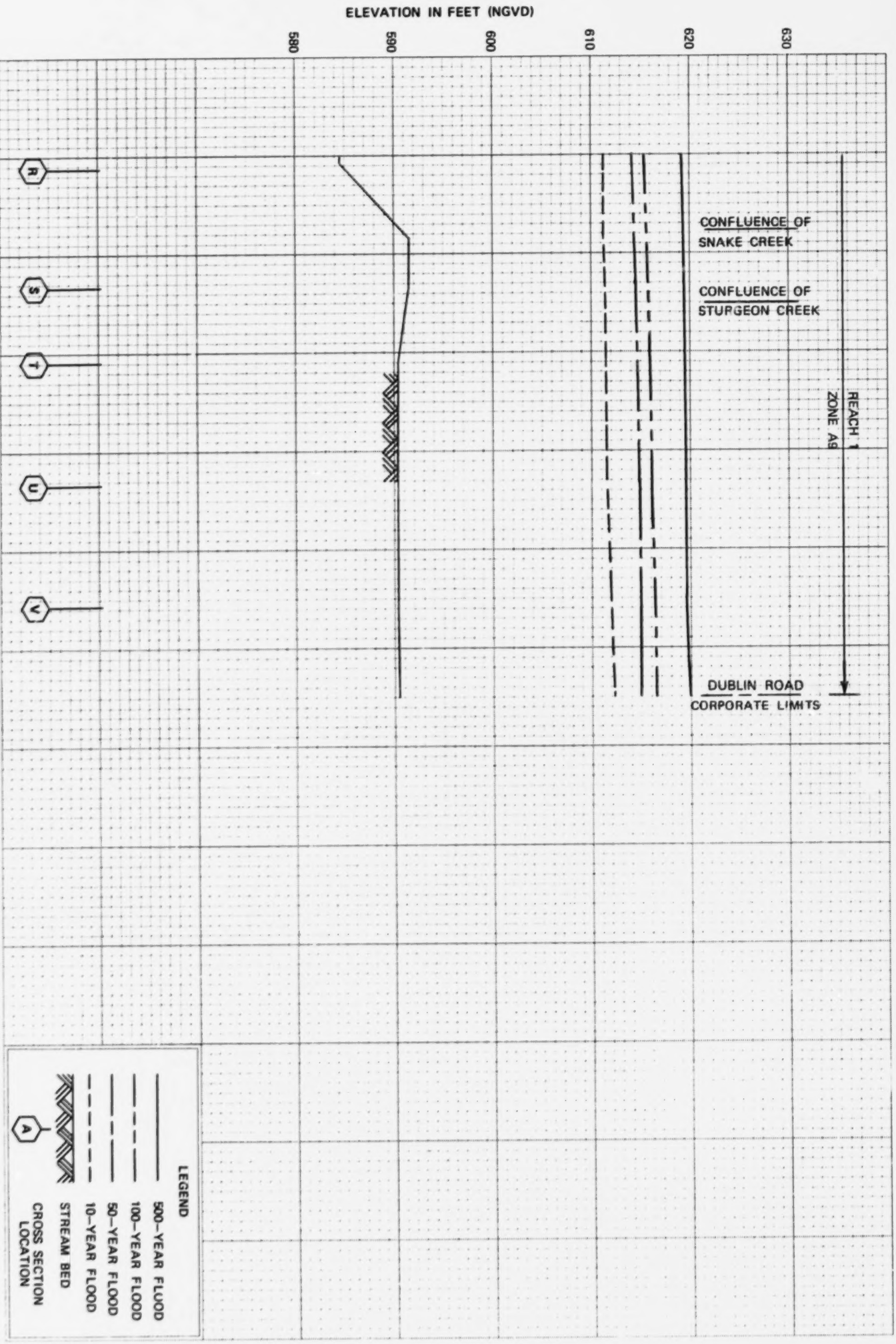


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02P

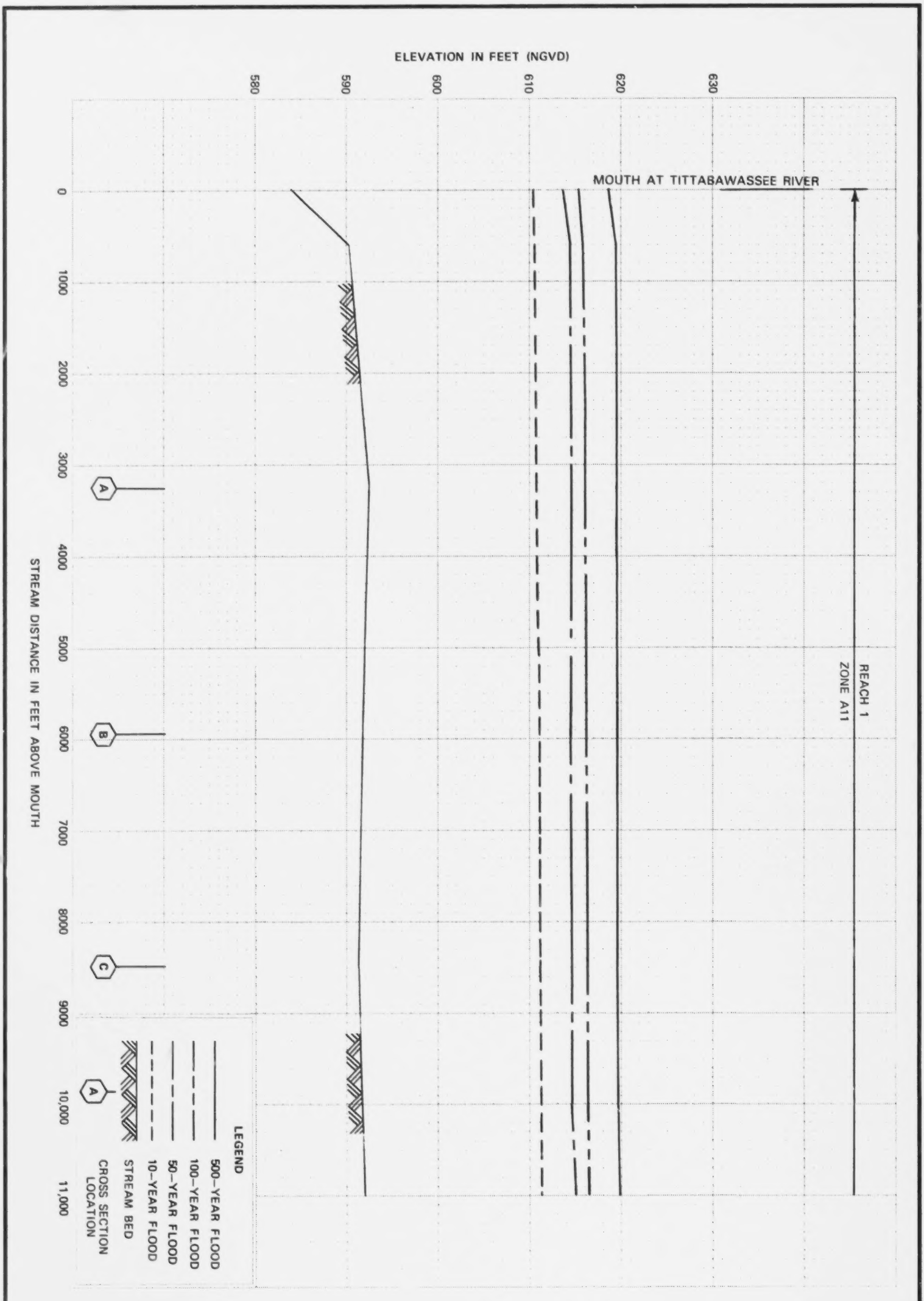
FEDERAL EMERGENCY MANAGEMENT AGENCY

**CITY OF MIDLAND, MI**

(MIDLAND AND BAY COS.)

**FLOOD PROFILES**

**TITTABAWASSEE RIVER**

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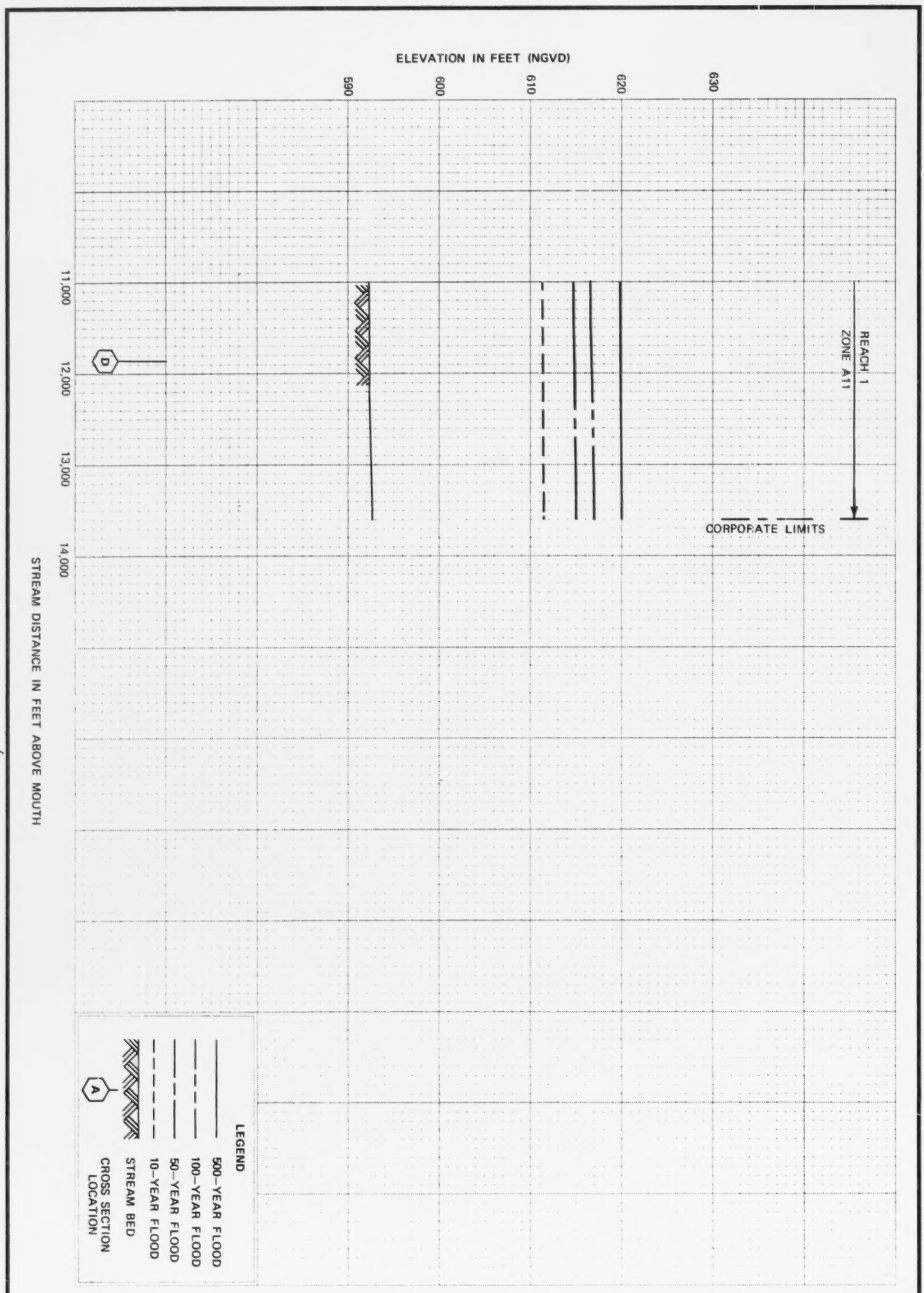
FEDERAL EMERGENCY MANAGEMENT AGENCY

**CITY OF MIDLAND, MI**

(MIDLAND AND BAY COS.)

**FLOOD PROFILES**

**CHIPPEWA RIVER**

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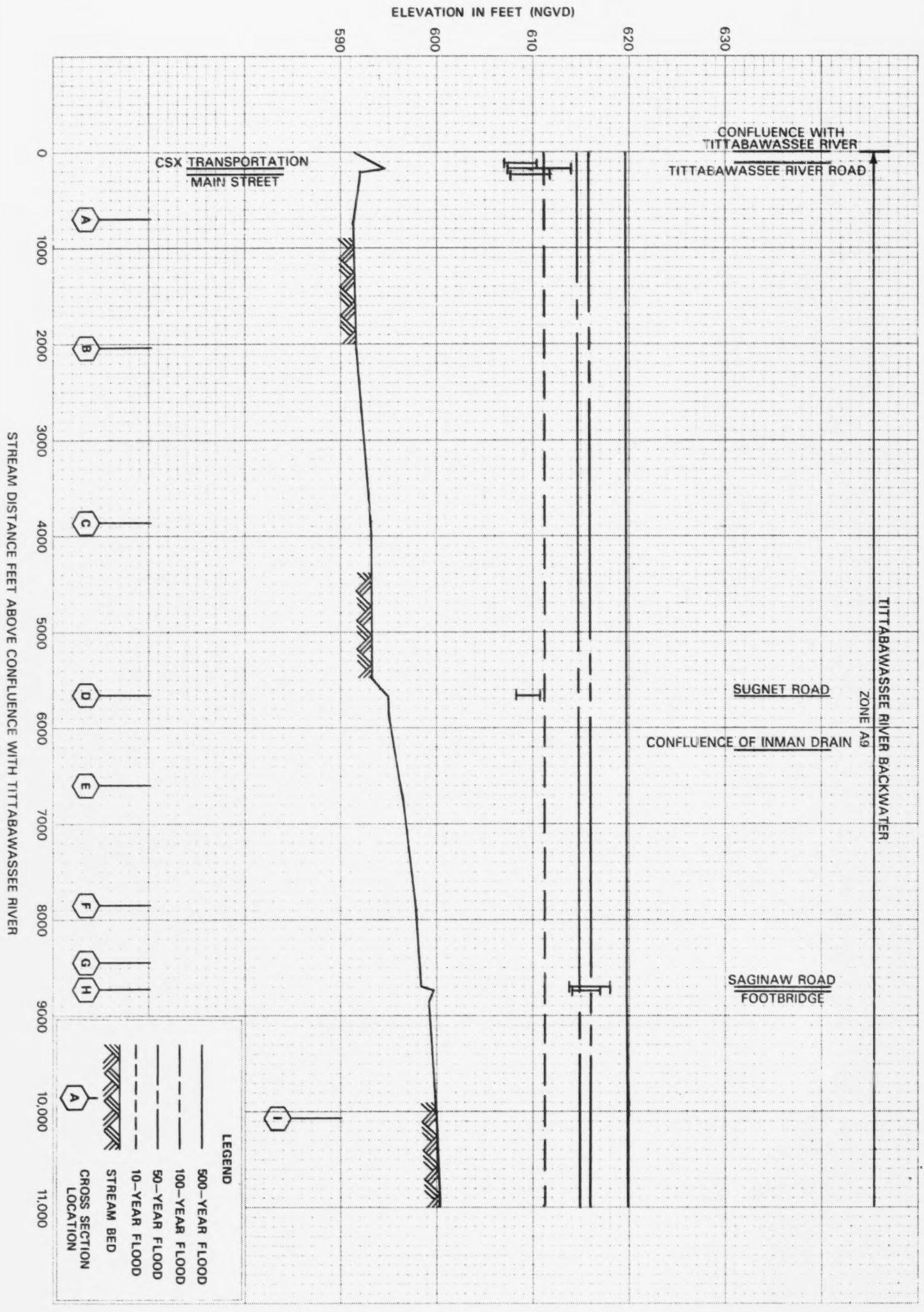
FEDERAL EMERGENCY MANAGEMENT AGENCY

**CITY OF MIDLAND, MI**

(MIDLAND AND BAY COS.)

**FLOOD PROFILES**

**CHIPPEWA RIVER**

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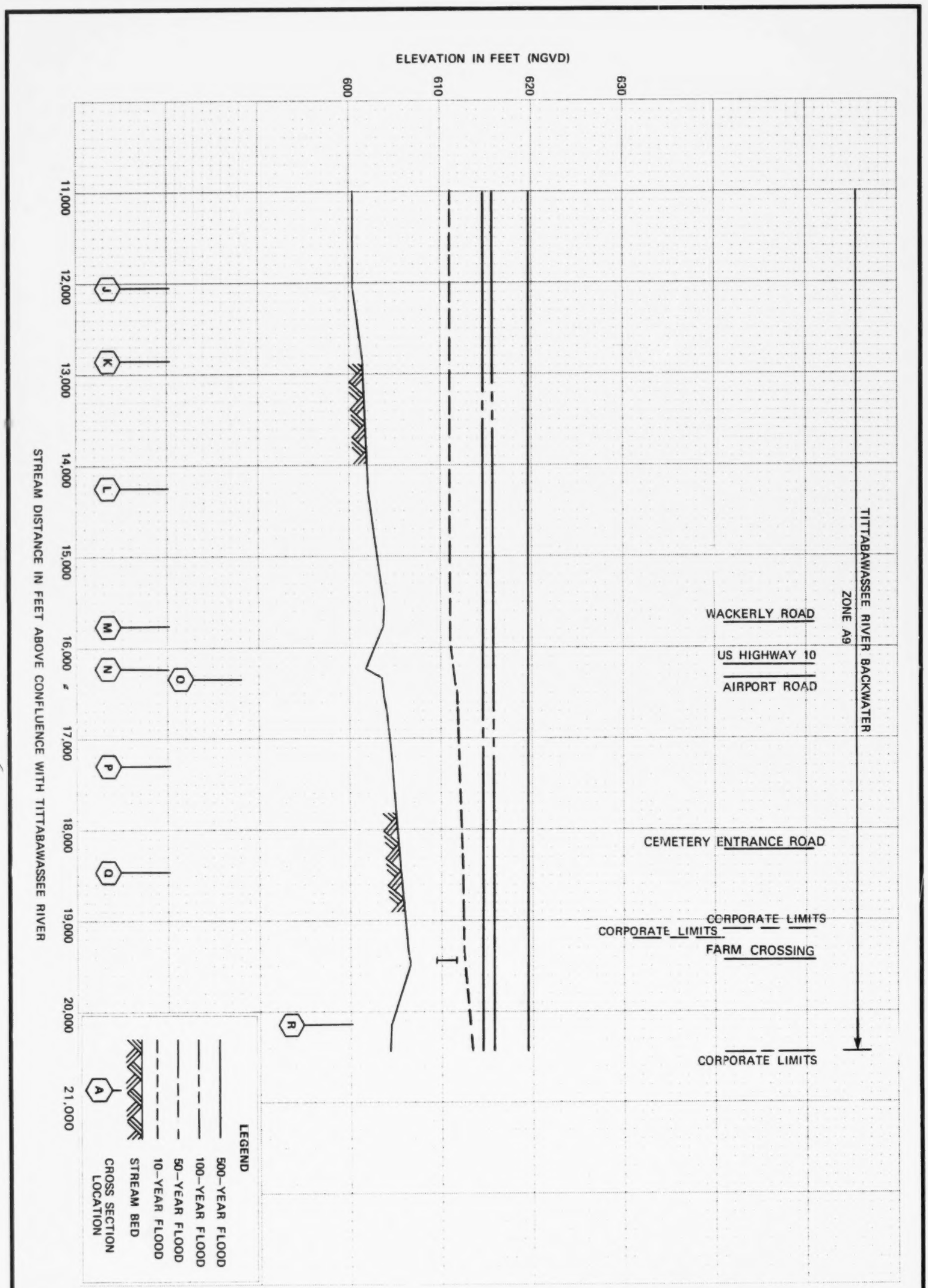
FEDERAL EMERGENCY MANAGEMENT AGENCY

**CITY OF MIDLAND, MI**
(MIDLAND AND BAY COS.)

**FLOOD PROFILES**

**STURGEON CREEK**

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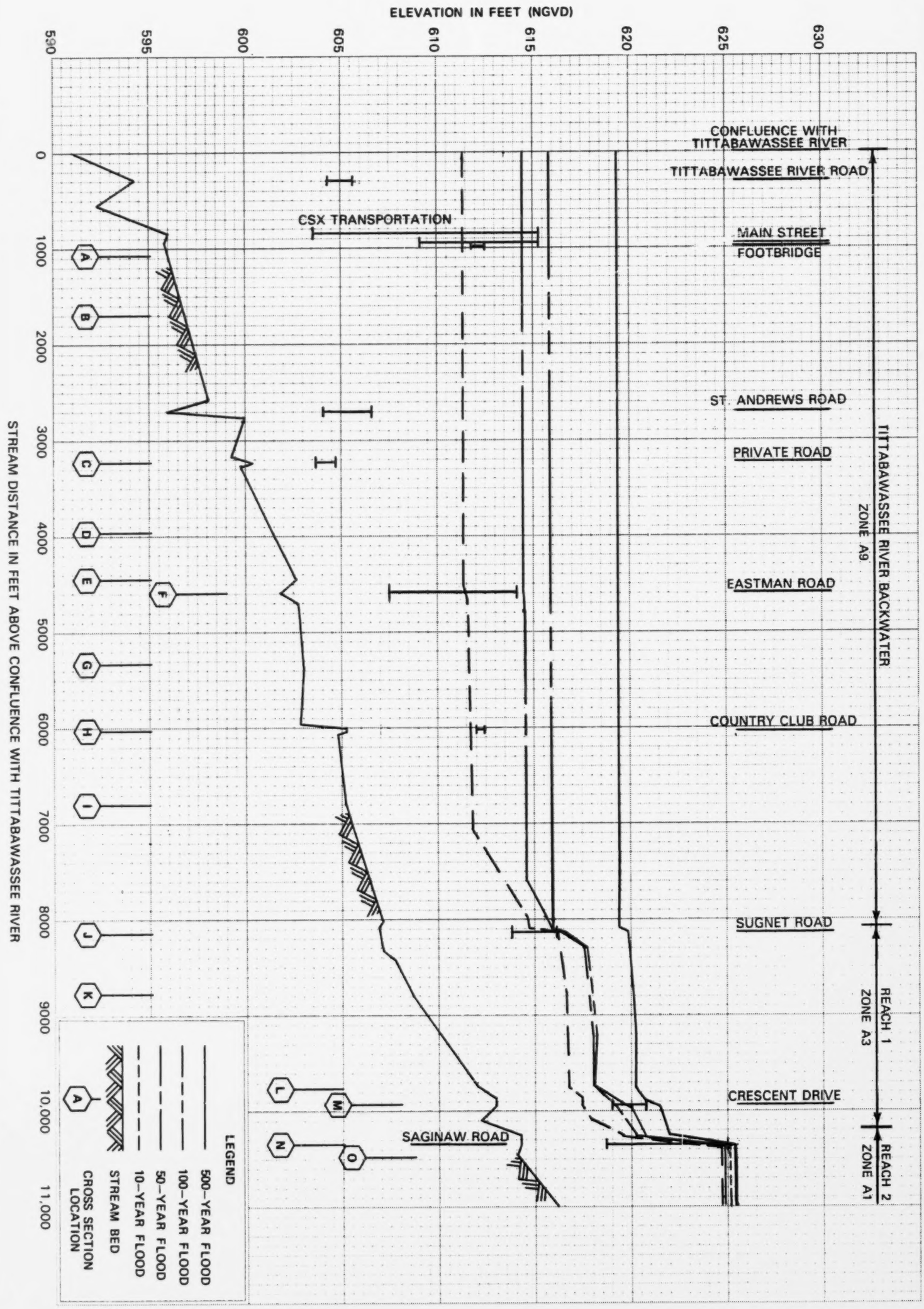


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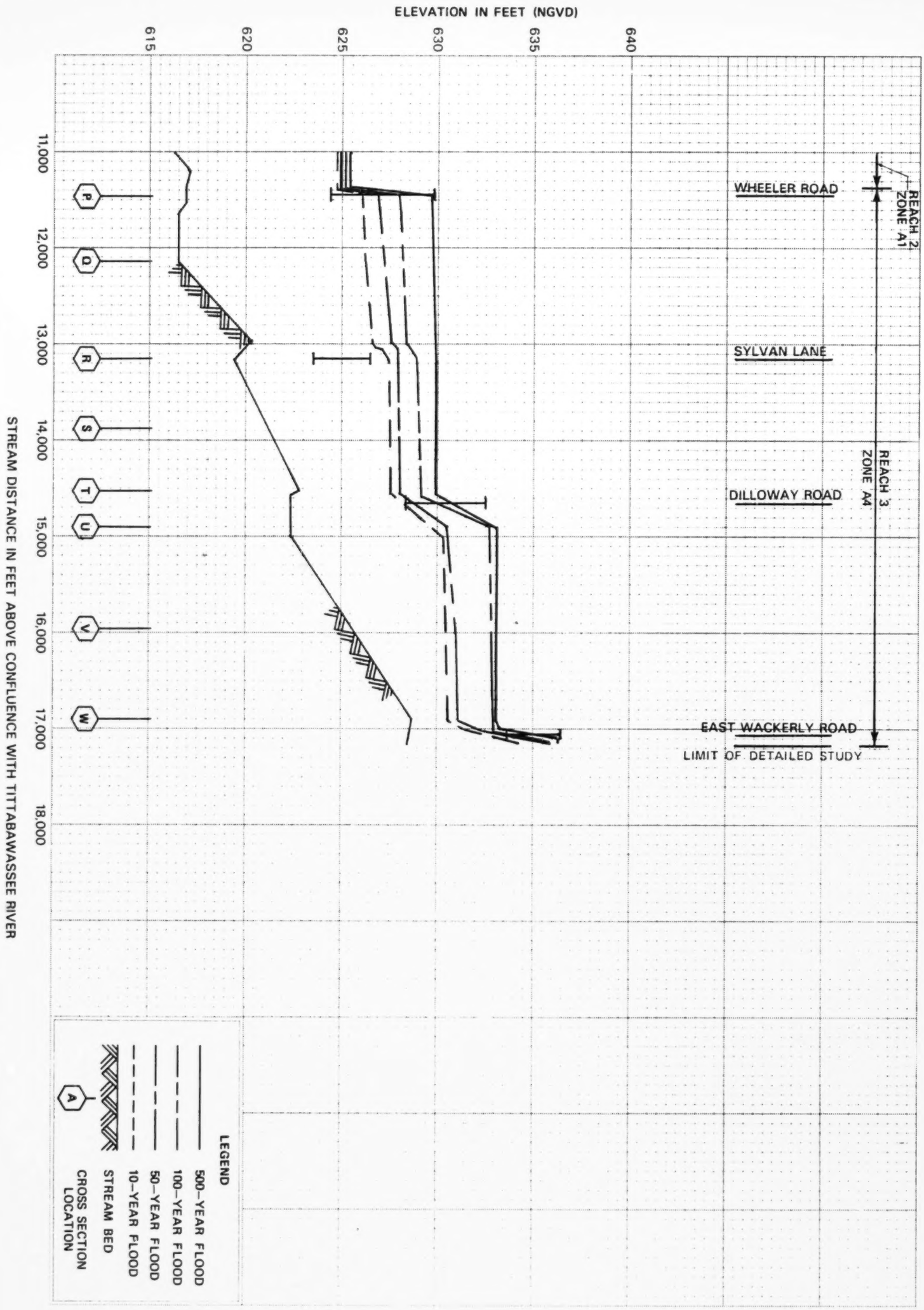
07P

FEDERAL EMERGENCY MANAGEMENT AGENCY

**CITY OF MIDLAND, MI**
(MIDLAND AND BAY COS.)

**FLOOD PROFILES**

**SNAKE CREEK**

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|---|---|---|
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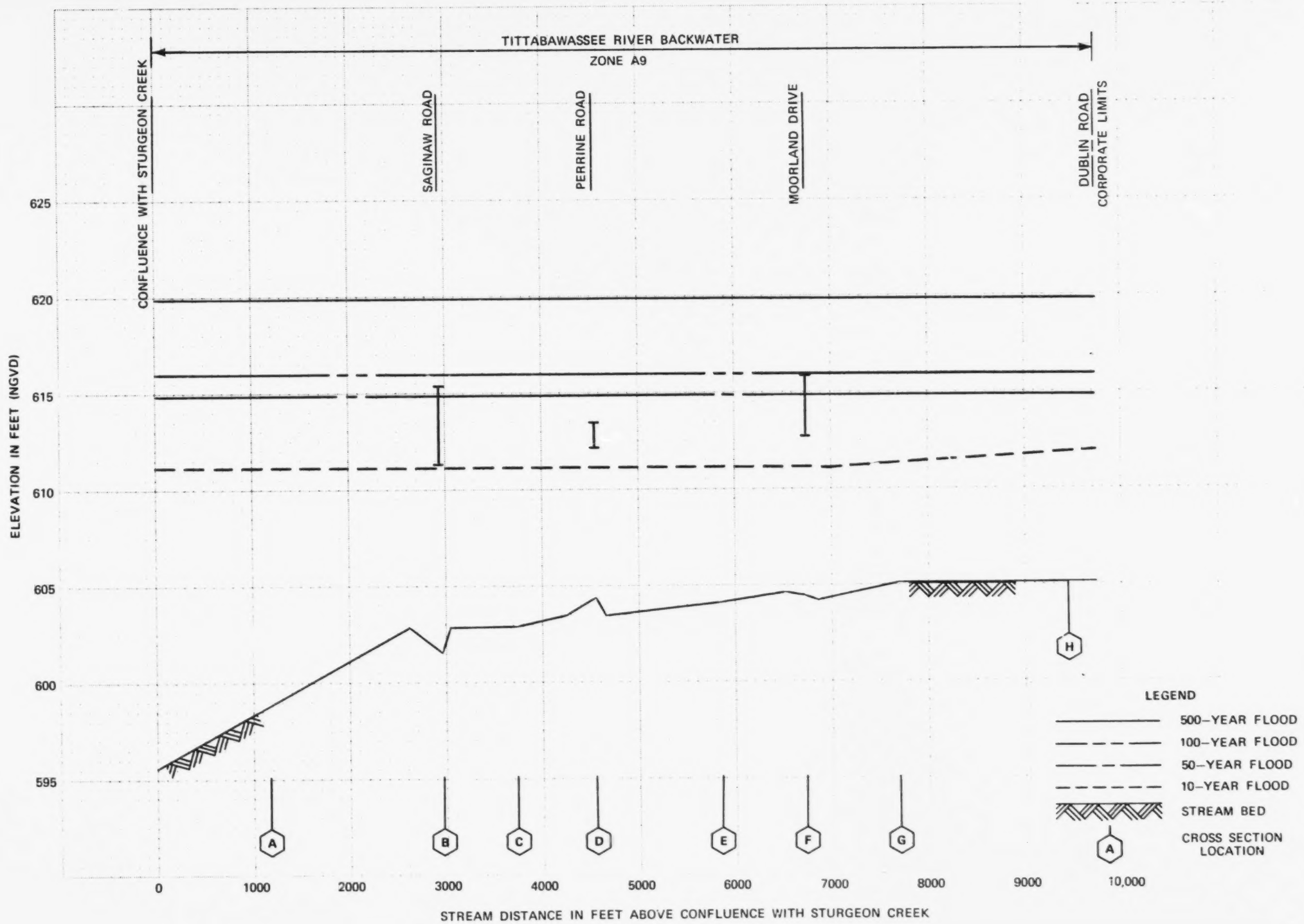


FLOOD PROFILES

INMAN DRAIN

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF MIDLAND, MI
(MIDLAND AND BAY COS.)

09P